Optimizing Labour Contractor Choices with MCDM: A Modern Approach to Construction Management

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Abstract. The construction industries are, to a great extent subordinate to variables such as the human workforce, which are incapable of being replaced with machines, therefore it may be a challenge within the range of the development segment to supply suitable labour contractor according to their determinations for creating effectiveness within the development venture. Multi Criteria Decision-Making (MCDM) system that helps to make decisions in situations where you need to consider multiple factors. This work is based on the critical issue of how to allocate labour contractors effectively in industries where labour deployment is critical. Web based solution using MCDM techniques includes an easy-to-use interface that provides stakeholders with a simple and transparent process for selecting labour contractors. Criteria include skills competency, availability schedules, track record, cost-efficiency and geographic location. Using a cross reference of different Hierarchy Process (AHP) approaches to determine which approach is best suited to the labour allocation scenario. Simulations and case studies are also used to test the system effectiveness and efficiency in real life situations. Web based solution enable timely and effective decision making, and also allows for continuous performance tracking and feedback loops. This research contributes to the advancement of labour allocation practices by introducing a robust web-based solution empowered by MCDM techniques. The proposed system offers a practical and innovative approach to address the complexities associated with labour contractor selection, ultimately leading to optimized resource utilization and enhanced project outcomes.

Keywords: Construction industries, Labour contractor, Connecting construction, MCDM, AHP, Web based solution.

1. Introduction

The construction industry plays an important role in the construction sector and contributes to the development. The construction sector has experienced rapid growth in recent years, which has helped improve the nation's economy. The challenges are in terms of cost, time,

machine, money, and quality, and the biggest challenge is labour availability and their allocation as per their expertise. The construction industries are largely dependent on factors like the human workforce, which they are unable to replace with machines, so it is a great challenge in the area of the construction sector to provide the appropriate labour according to their specifications for generating efficiency in the construction project. The workforce is one of the crucial aspects that affect the continuity and smooth implementation of construction projects. The availability of labour that has good scales is a key factor in getting the right quality product. Labour management in building construction means controlling the workforce problems, improving labour productivity, and reducing the time and cost overruns of projects.

In the context of building construction, labour management refers to the process of managing workforce issues, increasing labour productivity, and reducing the duration and cost of projects. Labour allocation and selection have a significant impact on a variety of industries. In each sector, the challenge is not only to identify the most suitable personnel for a particular task but also to ensure a balanced combination of talents, abilities, and preferences within the workforce. Making sure the right people are assigned to the right roles is key to efficiency. With the help of data analysis, it's easier to make decisions based on data. This can lead to higher productivity, cheaper costs, and better job satisfaction. It's all about finding the right people with the right skills and abilities for the right roles and then distributing tasks in a way that makes the most of them. This is the key to success in today's competitive industries. Finding the right construction contractor for your project is one of the most critical decisions a construction client needs to make if they want to get the job done right. It's also one of the most difficult because the construction industry is ever-changing and competitive. MCDM system that helps to make decisions in situations where you need to consider multiple factors. In order to make organizations more efficient and productive, it is important to find the right people for the job, use technology and data-driven methods, and follow the best practices for workforce management. This work shows that labour allocation and selection are key to success and staying ahead of the competition in today's fast paced business world.

2. MCDM for selection of Labour Contractor in Construction Management

To develop a system that establishes co-ordination and strengthens the relationship between the customer and the employee and also makes it easier to search for workers, saving time and effort [1]. This system allows to find the right job for you within your category throughout the year Selection methods employed by construction employers in the country are based on the applications containing essential information about education and work experience, internship performance and knowledge tests to measure job-specific knowledge [3] it is the vast process there for providing Web-Based Human Resource Sourcing System for Labour Contractor with using (MCDM) method. The contractor has an important role to play in the management of construction projects. Choosing the correct one is important, because it can lead to or ruin project [14].The main obstacles to finding qualified workers for construction projects such as a labour shortage are the focus of this study. The primary considerations for hiring workers for construction projects are the worker's conduct, years of experience, and the salaries offered [9]. In order to ensure timely completion of construction projects, a well-managed contractor selection process is essential. Selecting the right contractor is one of the most complex and challenging decision-making processes. Decision-makers do not usually share the same interest in finding the best contractors the criteria expressed in quantitative or qualitative information are often contradictory, enhancing one often leads to reducing the others [6]. Selecting the appropriate contractors

is crucial for a construction project as they are accountable for carrying out the primary tasks to ensure its completion. Selecting the appropriate criteria is crucial to achieve the desired outcome based on your decision-making preferences[13].Human resources are essential to organizations, as they provide insight, values, and characteristics that are essential for the success of the organization[10]. There are both quantitative and qualitative methods to determine the amount of work required [8].In fields where choosing the optimal course of action is highly intricate, MCDM offers reliable decision making. This survey's primary goal is to discover various applications and methodologies and provide the most reliable and efficient methodologies for choosing the appropriate substitute [4].MCDM tools to address the contractor selection problem [11]with implementation of multiskill labour utilization strategies are as follows: 5 to 20% labour cost savings, 35% reduction in required workforce, Average employment duration increases by 47%, increased earning potential for multiskilled construction workers [7].The traditional lowest bid method in the public sector is still widely used, and contracts are awarded on the basis of the lowest price. However, this approach has been criticized by many researchers as it may not guarantee the highest value in terms of timeliness and quality. In particular, tendering procedures are often subject to high-risk exposure, and the success of the project is closely linked to the ability to manage this risk effectively [12]. AHP is the most successful method to generate the efficiency of labour contractor; it applied to the issue of contractor selection as with regard to these issues, this is the assessment of the contractor as per pre qualification, evaluation, and selection process is necessary to meet project objectives. The AHP is a hierarchical model for contractor selection, is developed using the data gathered and used to create a contractor selection strategy that will benefit the stakeholders the best [16,19].The AHP is regarded as one of the most comprehensive systems for making decisions based on a variety of factors since it allows one to define the problem in a hierarchical manner and incorporates both quantitative and qualitative criteria. Making a problem hierarchy is the first step for solution. Creating a matrix of pair wise comparison judgments and assigning a nominal value to each level of the hierarchy constitute the second stage [17].As demand and supply of labour in the segment construction and gives the essential opportunity to acquire construction training [5].

The selection of labour contractors in construction management is a complex process influenced by globalization. Evaluating contractors against global standards is crucial, with experience, financial stability, and reputation identified as essential criteria for ensuring high performance in an international context [26]. Aligning selection criteria with project specific requirements is crucial for achieving project objectives [25]. The impact of contractor selection on project outcomes, such as cost, time, and quality, has been analyzed, revealing that a rigorous selection process is vital for risk mitigation and enhanced performance [24]. Additionally, a review of contractor performance evaluation methods demonstrates that both quantitative and qualitative metrics are required for project success [23]. Technological advancements, including digital tools and data analytics, enhance contractor evaluation processes [22]. Legal and ethical considerations are crucial in contractor selection [27]. Adherence to labour laws and ethical standards prevents disputes and ensures fairness. Guidelines are available for ethical decision-making stress transparency and fairness to maintain process integrity [28].

3. Methodology

The research begins with a comprehensive analysis of the challenges and issues prevalent in the process of selecting labour contractors within the construction industry. This involves examining factors such as Safety, skill level, duration, wages, compliance with Labour laws, and efficiency in construction. A thorough review of existing literature is conducted to gain insights into the current practices, methodologies, and technologies utilized in

Labour contractor management within the construction sector. This is the foundation for understanding the gaps and opportunities for improvement in the labour contractor allocation. Public Procurement Guidelines (Labour Laws) delves into the legal framework governing Labour procurement in the construction sector, focusing on relevant public procurement guidelines and Labour laws. This step ensures compliance with regulatory requirements and ethical considerations in contractor selection. Site visits are conducted to various under construction sites to observe firsthand the dynamics of Labour management, contractor performance, and on-site challenges. These visits provide valuable insights into the practical aspects of contractor selection and management. Quantitative and qualitative data are collected from various sources, including surveys, interviews, and questionnaire, to gather information on contractor performance, client requirements, and industry standards. Criteria for evaluating labour contractors are identified based on the research findings, industry standards, and stakeholder requirements. These criteria encompass factors such as experience, expertise, wages, duration, safety record, cost effectiveness, and compliance with regulations. A weightage scheme is devised to assign relative importance to each criterion based on its significance in contractor selection. This ensures a systematic and transparent approach to decision making, balancing competing priorities and objectives. Input from industry experts, stakeholders, and practitioners is solicited through interviews or expert panels to validate the identified criteria and weightage scheme. Expert opinions enrich the decision making process and enhance the credibility of the research findings through an AHP. An evaluation framework is developed to assess and compare Labour contractors based on the selected criteria and weightage scheme. This framework serves as a systematic tool for decision support and facilitates objective contractor selection. A web-based solution for Labour contractor management is designed and developed, incorporating the evaluation framework and features tailored to the needs of construction industry stakeholders.

3.1 Criteria's Selected for Individual Labour Contractor

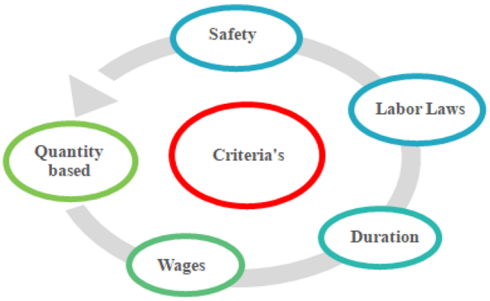


Fig. 1. Criteria's for Individual labour contractor

3.1.1 Safety of labour

The proactive safety management and its impact on reducing accidents are important [40]. Safety considerations are integral to effective project execution and management [41].Ensuring the safety and well being of labourers is paramount in construction management operations. All labourers must undergo comprehensive safety training before stepping foot on any construction site. Providing personal protective equipment (PPE) and enforce its consistent usage to mitigate workplace hazards effectively. Additionally, labourers must be covered by insurance for any workplace injuries, adhering strictly to local labour laws and regulations regarding working hours and conditions. Regular health

checks and screenings are conducted to ensure their fitness for the tasks involved. Continuous safety training is provided to all workers under supervision, accompanied by regular safety meetings addressing ongoing concerns and improvements. When selecting a labour contractor, it is essential to evaluate various factors, including demographic characteristics such as age, to ensure the establishment of a safe and efficient workforce.

3.1.2 Labour Laws

The influence of adherence to labour laws on construction project performance is explored, with emphasis placed on how legal compliance helps mitigate delays and cost overruns [31]. The relationship between construction contracts and labour laws is analyzed, highlighting the critical need for precise legal terms to ensure compliance and prevent disputes [33]. A comparative study on labour rights and industry practices is conducted, focusing on the impact of varying legal protections on industry practices and worker welfare [35]. Strategies for managing labour relations are examined, with an emphasis on the role of labour laws in effective workforce management and compliance [36]. Challenges in enforcing labour laws within the construction sector are identified, offering insights into obstacles and solutions for improving compliance [34]. Legal challenges related to labour law compliance in construction projects are addressed, providing guidance on navigating complex regulatory environments [37]. The impact of labour laws on construction project success is assessed, demonstrating how legal adherence affects project outcomes such as cost and quality [32].
Ensuring compliance with legal regulations and fostering a safe and respectful work environment are core principles in labour recruitment process. Necessary licenses and permits are required as per local laws, demonstrating commitment to lawful practices. Compliance with minimum wage regulations specific to the type of construction work involved is a non-negotiable aspect of our operations, ensuring fair compensation for all workers. Proper documentation and contracts outlining terms of employment, working hours, and benefits are provided to each labourer, promoting transparency and clarity in our working relationships. It is to be dedicated to maintaining a harassment free work environment, strictly adhering to anti discrimination laws and regulations to protect the rights and dignity of every individual. Additionally verified the legal employment status of each labourer, ensuring they are eligible to work in the country, thus upholding commitment to legal and ethical labour practices.

3.1.3 Duration criteria to work on site

Labour working criteria in construction affects labour efficiency, project success and project performance. Flexibility in working hours is the integral to construction project success. Acknowledgement of extended working hours or overtime may be necessary to meet project deadlines effectively. Labours are prepared to adapt to changes in the project schedule, understanding the occasional need for adjustments based on project needs. They are comfortable with occasional extended workdays to ensure timely completion of tasks. By developing contingency plans to address potential delays, ensuring minimal disruption to the project timeline and implementing penalties or incentives based on meeting or exceeding project timelines to maintain accountability and motivation among the workforce. Certain phases within the project may require longer hours, and labourers are committed to ensuring their completion. Seasonal variations in working hours, such as longer hours during peak periods, are also considered and accommodated to optimize project efficiency

3.1.4 Wages of Labours

Ensuring fair and compliant wages is a top priority in construction practices. Wage rates affect various outcomes in construction projects, including project cost and quality, emphasizing the economic implications of wage decisions [38]. Wage strategies impact project success and worker engagement [39].Adhere strictly to prevailing minimum wage regulations within the industry, offering wages that meet or exceed these standards. System for calculating and disbursing wages is clear and transparent, incorporating any necessary deductions or bonuses. Recognize the challenges of working in certain conditions and provide hazard pay or additional compensation accordingly. Regular reviews of wages are conducted to ensure they align with industry standards and account for cost of living adjustments. Labourers receive overtime pay for any hours worked beyond the standard working hours, promoting fair compensation for their efforts. Wages are paid regularly and punctually, without delays or discrepancies, fostering trust and stability among our workforce. Mechanisms in place for adjusting wages based on skill level or experience within the construction field, promoting career progression and recognition of expertise. Additionally, labourers receive written documentation detailing their wage structure, ensuring transparency and clarity regarding any potential changes over time.

4. Data analysis by AHP methodology

AHP lies in its ability to handle both qualitative and quantitative data, offering a structured decision-making process that enhances transparency and consistency [29]. However, limitations include potential biases in pair wise comparisons and the complexity of managing large decision matrices [30]. Thomas Saaty developed the Analytic Hierarchy Process (AHP) in the 1970 to offer a straightforward yet theoretically solid multiple criteria process for assessing alternatives. [18] It attempts to measure the relative priorities for a given set of alternatives on a ratio scale, based on the decision maker's judgment. It emphasizes the significance of the decision maker's intuitive judgment in addition to the regularity with which the alternatives are compared during the decision-making process. AHP can be found in a wide range of domains, including project management, contractor management, engineering challenges, and portfolio also selection models are solved using methodology. Hierarchical structure analysis principles are used to provide a methodical solution to the alternative selection and justification problem. Usually, decision makers discover that making interval judgments instead of fixed value judgments gives them greater confidence. This approach can be used when a user desire is imprecise and not clearly stated. Expert opinions and multi-criteria evaluation are included in AHP; human indecision cannot be reflected in it. Because decision makers' definitive judgments are taken into account by the traditional AHP increases the flexibility of the comparison process and helps to explain the preferences of experts. A challenging MCDM challenge is broken down into a methodical hierarchy technique using the AHP. The structure of m*n matrix where number of criteria’s are the subjected to correlation in between them is evaluated with the AHP technique in which It also includes pair wise comparison of different alternatives for different criterion. A matrix is created in terms of each criterion using the relative relevance of the options. The foundation of the AHP is priority theory. It addresses complicated issues that need taking into account multiple criteria or options at once. Since problem is constructed into a hierarchical structure, the importance of each element becomes clear and no bias is allowed in decision making. Process of analysis hierarchy when a decision maker has to choose between several criteria, the AHP method is used to rank the options and choose the best one. Decision makers evaluate each alternative based on its performance relative to predefined criteria, rank them accordingly, and select

the optimal option that meets or exceeds the minimum acceptable score. Fig no. 2 shows the data analysis methodology.

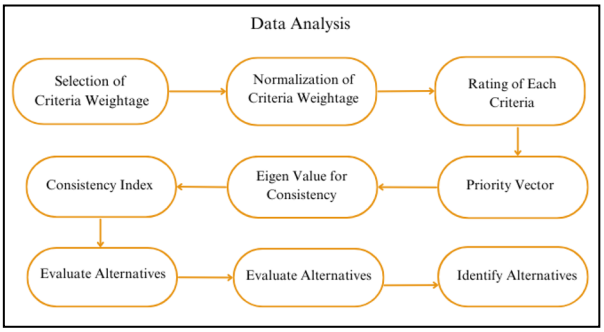


Fig. 2. Methodology for data analysis

Table no. 1 includes the standard weightages of the different criteria which are assumed in this study. Table no. 2 is the findings of weightages according to the data collected from different sites. Table no 3 is the normalization of weightages of criteria. Table no.4 is the rating of each criterion according to calculations. Table no. 5 is the generated rating for different labour contractor according to the criteria consideration. Table no. 6 is the priority vectors, this is the normalized principal Eigen vector and it can be obtained by averaging across the rows. The normalized principal Eigen vector is also called priority vector. Since it is normalized, the sum of all elements in priority vector is 1.

Table 1. Standard Weightage Criteria

Sr. No.	Standard Weightage	
1	Equally Preferred	1
2	Moderately Preferred	3
3	Strongly Preferred	5
4	Very Strongly Preferred	7
5	Extremely Preferred	9

Table 2. Weightages According to different Criteria

Criteria's	Safety	Wages	Duration	Labour Laws
Safety	1.00	5.75	6.50	5.25
Wages	0.17	1.00	4.25	3.00
Duration	0.15	0.24	1.00	3.75
Labour Laws	0.19	0.33	0.27	1.00
	1.52	7.32	12.02	13.00

Table 3. Normalization of Criteria's Weightage

Criteria's	Safety	Wages	Duration	Labour Laws
Safety	0.66	0.79	0.54	0.40
Wages	0.11	0.14	0.35	0.23
Duration	0.10	0.03	0.08	0.29
Labour Laws	0.13	0.05	0.02	0.08

Table 4. Rating of Each Criteria

Criteria's	**Safety**	**Wages**	**Duration**	**Labour Laws**
Safety	0.66	0.79	0.54	0.40
Wages	0.11	0.14	0.35	0.23
Duration	0.10	0.03	0.08	0.29
Labor Laws	0.13	0.05	0.02	0.08

Table 5. General Rating

Sr. No.	**Generated Rating %**
1	59.73
2	20.89
3	12.63
4	6.75

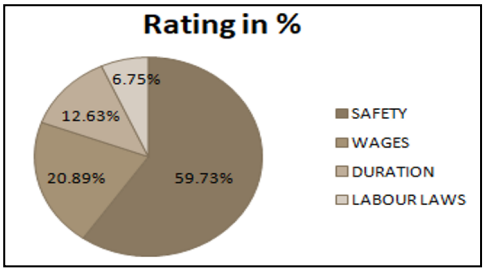


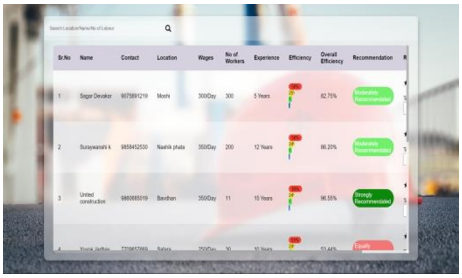
Table 6. Priority Vector

Sr. No.	Priority Factor
1	0.59727185
2	0.20890795
3	0.12629039
4	0.06752982

Efficiency index is calculated by finding Eigen value of consistency and consistency index So the Eigen Value for Consistency is 4.831195 and Consistency Index is 0.2770. While calculating both finally the Efficiency Index is 0.307850.

5. Web Based solution

The website provides a user-friendly platform for contractor evaluation, selection and monitoring. The findings of the research, including the evaluation results, are presented and discussed in detail. The implications of the findings for Labour contractor management in the construction industry are analysed, addressing both theoretical and practical considerations. The research concludes by summarizing the key findings, highlighting the significance of the proposed web-based solution, and offering recommendations for future research and implementation. The conclusion emphasizes the potential of the developed methodology to enhance efficiency, transparency, and effectiveness in Labour contractor management within the construction sector. User interfaces for Labour contractor management are given below in fig. 3.



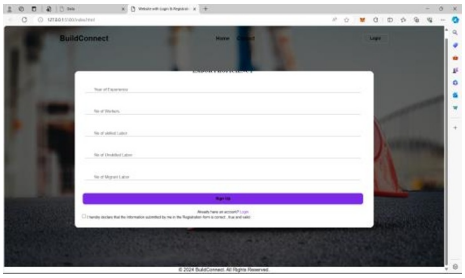


Fig. 3. Web Based Solution

Connecting Construction: A Web-Based Solution for Labour Contractor Management has yielded significant results in revolutionizing the management of labour contractors within the construction industry through the implementation of the web-based platform, efficiency has been markedly improved, with a reduction in manual paperwork and administrative tasks. Communication between construction companies and labour contractors has been streamlined, leading to fewer misunderstandings and delays in project timelines. Moreover, the platforms tracking and reporting capabilities have provided invaluable insights into labour contractor performance, hours worked, and project progress, enabling better decision-making and resource allocation. Cost savings have been realized through optimized labour management processes, allowing for more accurate budgeting and resource utilization. Additionally, the scalability of the solution has facilitated the handling of larger projects and the expansion of operations without significant additional overhead. Compliance with labour laws and regulations has been enhanced, reducing risks associated with contractor management. Overall, user satisfaction has been high, with stakeholders finding the platform intuitive and beneficial to their work, marking a significant advancement in labour contractor management within the construction sector. If the value of efficiency index is smaller or equal to 10%, the labour contractor is acceptable. Selection of labour contractor is done as per the designed labour contractor efficiency index which is in between 0 to 10. Various parameters are designed as per the labour contractor efficiency index generated.

6. Conclusion

The construction industry heavily relies on human labour, which machines cannot fully replace, making it challenging to find suitable labour contractors to optimize project efficiency. Traditional methods for labour allocation often fall short because they do not consider multiple factors such as skills, availability, costs, and location. To address this issue, a web-based solution utilizing Multi Criteria Decision Making (MCDM) techniques has been developed. This system offers an intuitive interface that simplifies and clarifies the selection process for labour contractors. It evaluates potential contractors based on a range of criteria, including skills, availability, track record, cost-efficiency, and geographic location. By applying different Hierarchical Process approaches, the system identifies the most effective method for labour allocation. Simulations and case studies have shown that this approach significantly improves labour allocation outcomes, workforce utilization, cost-efficiency, and project execution. The web-based solution facilitates timely, effective decision making and provides continuous performance tracking and feedback. This research advances labour allocation practices by offering a practical, innovative solution that enhances resource utilization and project results.

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